Pilot-in-the-loop Method Development

2012 Basic and Applied Research in Sea-Based Aviation

ONR #BAA12-SN-0028

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1   PROJECT OVERVIEW

The goal of this project is to integrate novel numerical modeling and computer hardware approaches to compute the non-linear aerodynamic coupling between the ship and aircraft in such a way that execution times are at real-time speeds, allowing for pilot-in-the-loop CFD to be integrated in the piloted flight simulation environment. To achieve the speed gains required, three areas will be targeted for implementation into the CFD simulation framework: (1) numerical algorithms, (2) novel domain boundaries, and (3) Graphical Processing Unit (GPU) hardware.   A framework will be established to link the CFD with realtime simulations.   A building block approach will be employed to first demonstrate non-realtime integration of the CFD simulation framework with helicopter flight dynamic models, then realtime execution for a minimum fidelity airwake/aircraft simulation, then build to higher fidelity realtime simulations.

1.1   Project Technical Objectives

The project involves the following seven tasks to accomplish the technical objectives of the project:

> Task 1: Implement modular implicit/explicit solver
>
> Task 2: Apply structured numerics
>
> Task 3: Apply subdomain with immersed boundary
>
> Task 4: Implement higher order explicit solver for GPU execution
>
> Task 5: Integrate with the GENHEL-PSU flight dynamics model
>
> Task 6: Demonstrate flight simulation in the PSU Rotorcraft Simulation Facility
>
> Task 7: Demonstrate flight Simulation in NAVAIR Manned Flight Simulator

2   WORK SUMMARY

During this reporting period efforts were focused on installing the license server and CRUNCH CFD solver onto Penn State University computing clusters, and providing training for PSU researchers in the operation of the code.   Training was provided for general code operation, in addition to specific instruction for setting up and running cases with the incompressible solver module of the code.   Initial steady state and unsteady CRUNCH CFD simulations were performed by PSU researchers for a SFS2 (Simple Frigate Shape) airwake grid provided by NAVAIR for use by PSU.

The SFS2 airwake grids were provided by NAVAIR for sub-scale wind tunnel test geometry.   The grids were provided in COBALT format which were processed into CRUNCH format by the PRECRUNCH preprocessor utility. CRAFT Tech assisted PSU researchers in setting up a 0º wind-over-deck case (ship model aligned with the test section flow direction). An illustration of the SFS2 geometry and grid showing the test section walls and surface mesh is shown in Figure 1. Figure 2 shows the CRUNCH CFD interface and input settings for the case.
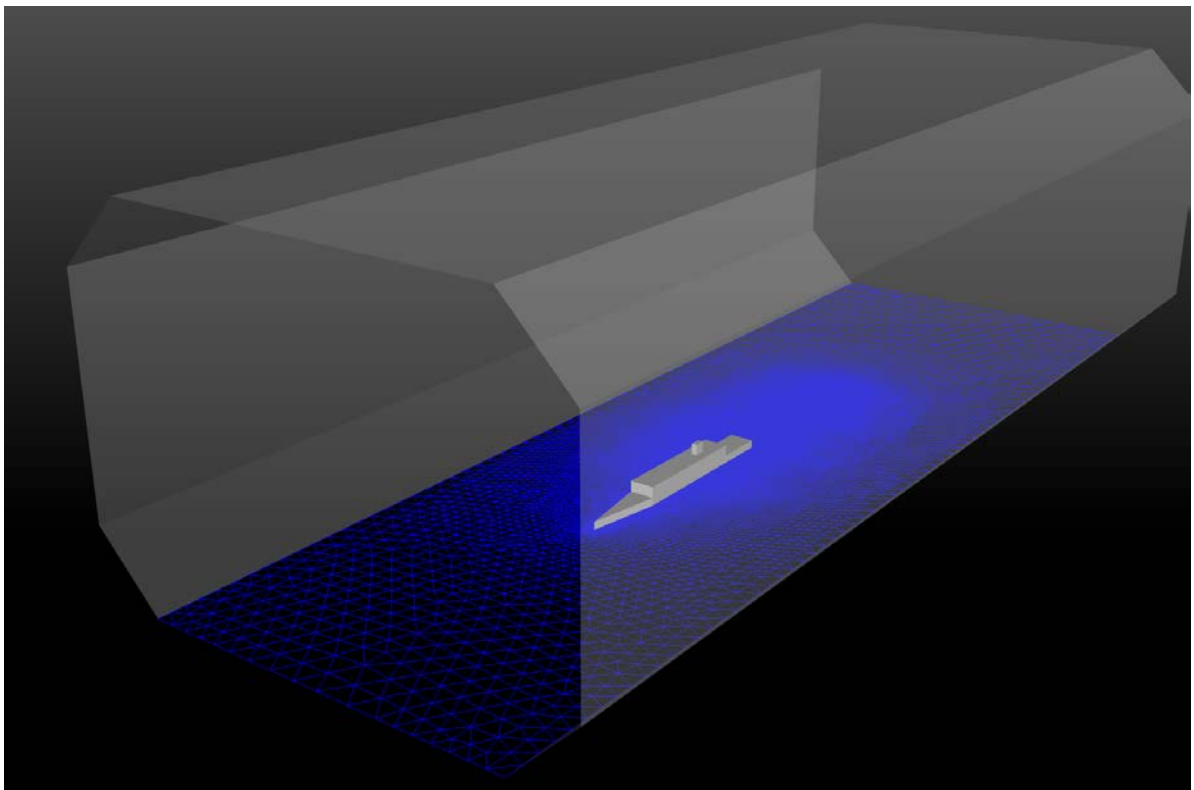

Figure 1: SFS2 Wind Tunnel Scale Model and CFD grid.
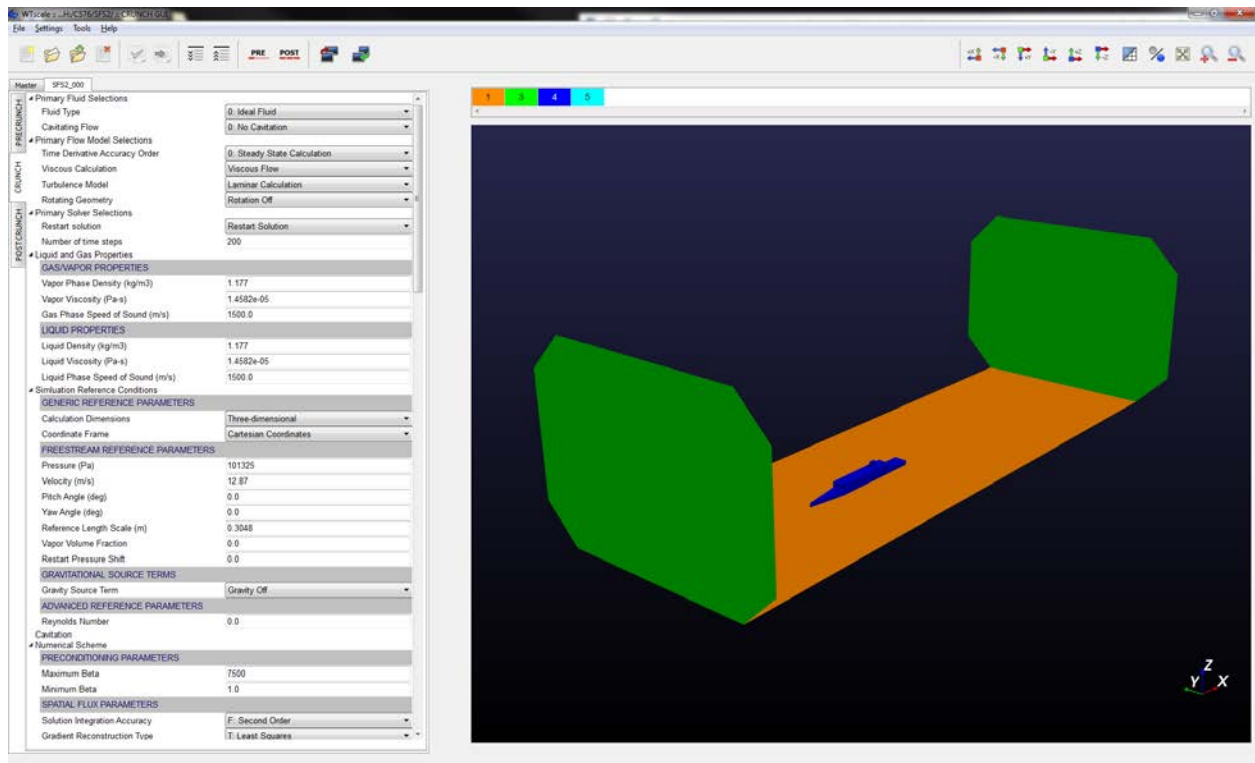
Figure 2: CRUNCH CFD Graphical User Interface Showing Setup of Solver Inputs for the SFS2 Winmd Tunnel Scale Cases.

PSU researchers are testing the operation of the code on their linux cluster using this SFS2 wind tunnel case. Eventually, a full scale version of the SFS2 grid without wind tunnel walls is desired for generating airwake solutions that can be used to couple with the GENHEL model. CRAFT Tech is currently generating full scale versions of the case.

3   TECHNICAL/COST STATUS AND PROBLEM AREAS

No technical or financial problems have been encountered.

4   MEETING AND/OR TRAVEL

N/A

5   CONTRACT SCHEDULE

The program is proceeding as planned.

6   PLANNED ACTIVITIES FOR NEXT REPORTING PERIOD

During the next reporting period, the full scale SFS2 grid will be completed and provided to PSU. CRAFT Tech will assist PSU in setting up and running the case, and in determining the best solver parameters for obtaining good unsteady airwake results.

Additionally, CRAFT Tech is currently working on a full scale LHD case for performing Task 2 structured and unstructured simulations.

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